



## COURSE CONTENT

<b>Academic Year</b>	2022/2023	<b>Semester</b>	2
<b>Course Coordinator</b>	Asst. Prof. Zhao Wenting		
<b>Course Code</b>	CH4303		
<b>Course Title</b>	Bioseparations		
<b>Pre-requisites</b>	CH1131/BG1131/CB1131		
<b>No of AUs</b>	3		
<b>Contact Hours</b>	<i>39 hours lecture, 0 hours tutorial</i>		
<b>Proposal Date</b>	<i>28<sup>th</sup> Sept. 2018</i>		

### Course Aims

This course provides an insightful overview of the fundamentals of bioseparations processes used for bioproducts in the pharmaceutical, biotechnology and food industries. It helps you to gain a solid understanding of the principles, application and scale-up of bioseparation processes that the scientist and engineer are most likely to encounter in the laboratory and in industrial settings. It also introduces new concepts and emerging technologies that are likely to benefit biochemical product recovery in the future.

### Intended Learning Outcomes (ILO)

Upon successful completion of this course, you will be able to:

- 1) Explain the principles of technologies used for bioproduct separations;
- 2) Analyze and interpret bioseparation data;
- 3) Evaluate choices for a specific bioseparation problem.
- 4) Develop conceptual process designs for bioseparation applications.

### Course Content

Key topics covered in this course are:

- 1) Classifications of bioproducts and bioseparations;
- 2) Analytical Methods and Bench Scale Preparative Bioseparations;
- 3) Key technologies used in bioseparation, e.g. cell lysis and flocculation, filtration, chromatography, extraction, and drying;
- 4) Bioprocess design and economics;
- 5) Emerging technologies for bioseparations.

**Assessment (includes both continuous and summative assessment)**

You will be assessed by 100% continuous assessment (CA).

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment rubrics
1.CA1: Assignments	1,2,3,4	EAB SLO a, b	30%	Individual	Refer to appendix 1
2.CA2: Quiz	1,2	EAB SLO a, b	30%	Individual	Refer to appendix 1
3.CA3: Project Presentation	1,2,3,4	EAB SLO a, b, c, d, f, i, j	30%	Team	Refer to appendix 2
4.CA3: Peer Evaluation	2,3	EAB SLO a, c, i, j	10%	Team	Refer to appendix 3
Total			100%		

**Formative feedback**

Assignment solutions and Quiz answers will be discussed in class.  
Overall performance of project presentations will be discussed in class.

**Learning and Teaching approach**

Approach	How does this approach support students in achieving the learning outcomes?
Lecture	Formal lectures on the topics with in-class discussions using incomplete handouts to encourage you to participate in class.
Case Studies	This will engage you in research and reflective discussion as well as encourage higher order thinking.
Project presentation	This helps you to achieve one or more of the outcomes, as you need to do self-study, research, and then make classroom presentation. (The class is split into 10 presentation teams. 5 groups will make presentation with Q&A in each week. You will be grouped into 3-5 students per team.)

## Reading and References

- Bioseparations Engineering: Principles, Practice, and Economics, Michael R Ladisch, Wiley, 1st Edition, 2001.
- Bioprocess Engineering: Basic Concepts, Michael L. Shuler and Fikret Kargi, Prentice Hall, 2nd Edition, 2001.
- Principles of Bioseparations Engineering, Raja Ghosh, World Scientific, 2006.
- Bioseparations Science and Engineering, Roger G. Harrison, Paul W. Todd, Scott R. Rudge, and Demetri P. Petrides. Oxford University Press, 2nd Edition, 2015.

## Course Policies and Student Responsibilities

### 1) General:

Students are expected to complete all online activities and take all scheduled assignments, quizzes, project presentations and term report by due dates. Students are expected to take responsibility to follow up with course notes, assignments and course related announcements. Students are expected to participate in all project presentation discussions and activities.

### 2) Continuous assessments:

Students are required to attend all continuous assessments.

### 3) Absenteeism:

Continuous assessments make up a significant portion of students' course grade. Absence from continuous assessments without officially approved leave will result in no marks and affect students' overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for in-class presentation activities.

## Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the [academic integrity website](#) for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

**Course Instructors**

Instructor	Office Location	Phone	Email
ZHAO, Wenting	N1.3-B3-10	6514-1028	wtzhao@ntu.edu.sg

**Planned Weekly Schedule**

Week	Topic	Course LO	Readings/ Activities
1	Introduction to Bioproducts and Bioseparations	1	Face to face lecture
2	Analytical Methods and Bench Scale Preparative Bioseparations	1,2	Face to face lecture Assignment 1
3	Cell Lysis and Flocculation	1,3,4	Face to face lecture LAMS project assignment
4	Filtration and Sedimentation	2,3	Face to face lecture Assignment 2
5	Liquid Chromatography and Adsorption	2,3	Face to face lecture
6	Extraction and Precipitation	2,3	Face to face lecture Assignment 3
7	Crystallization, Evaporation and Drying	3,4	Face to face lecture
Recess			
8	Quiz (2.5 hr)	1,2	In class CA, quiz
9	Bioprocess Design and Economics	1,2	Face to face lecture
10	Emerging Technologies for Bioseparation 1.	2,3	Face to face lecture
11	Emerging Technologies for Bioseparation 2.	2,3	Face to face lecture
12	Project Presentation 1	3,4	Group Presentation and Evaluation
13	Project Presentation 2	3,4	Group Presentation and Evaluation

## Appendix 1: Assessment Criteria for Quiz and Assignment

<b><u>Criteria</u></b>	<b><u>Unsatisfactory: &lt;40%</u></b>	<b><u>Borderline: 40% to 49%</u></b>	<b><u>Satisfactory: 50% to 69%</u></b>	<b><u>Good: 70% to 89%</u></b>	<b><u>Exemplary: &gt;90%</u></b>
<b><u>Knowledge</u></b> Understanding the principles and technologies used for bioseparation.	Lacks understanding of principles and concepts used in bioseparation.	Partial understanding of principles and concepts used in bioseparation.	Reasonable understanding of principles and concepts used in bioseparation.	Good understanding of principles and concept used in bioseparation; and able to compare the pros and cons of different technologies.	Comprehensive understanding of theories and concepts used in bioseparation; and able to identify current limitations and suggest alternatives.
<b><u>Analysis</u></b> The ability to analyse and interpret bioseparation process data.	Unable to understand parameters and data generated in bioseparation processes.	Can identify and partially understand parameters and data generated in bioseparation processes.	Can read and understand parameters and data generated in bioseparation processes well.	Can understand and interpret parameters and data generated in bioseparation processes well, and apply the knowledge to analyse them.	Can understand and interpret parameters and data generated in bioseparation processes well, and apply the knowledge to analyse them and provide predictions.

## Appendix 2: Assessment Criteria for Project Presentation

<b><u>Criteria</u></b>	<b><u>Unsatisfactory: &lt;40%</u></b>	<b><u>Borderline: 40% to 49%</u></b>	<b><u>Satisfactory: 50% to 69%</u></b>	<b><u>Very good: 70% to 89%</u></b>	<b><u>Exemplary: &gt;90%</u></b>
<b><u>Comprehension</u></b> The ability to comprehend multiple bioseparation modules and their connection to design effective separation process for popular bioproducts.	Unable to understand the basic design components and recognize various process modules used in bioseparation.	Partially understand the basic design components and recognize various process modules used in bioseparation.	Understand the basic design components and recognize various process modules used in bioseparation.	Understand the basic design components and process modules very well, and most likely can predict the performance.	A thorough understanding of the design components and process modules in bioseparation, and can suggest alternative designs.
<b><u>Application</u></b> Applying theories and use appropriate methods to diagnose faults in bioseparation process.	Unable to understand application requirement of various bioproducts, and apply the knowledge to dissect and modify their bioseparation process.	Can partially understand application requirement of various bioproducts, and apply the knowledge to dissect and modify their bioseparation process.	Can understand application requirement of various bioproducts, and apply the knowledge to dissect and modify their bioseparation process.	Can understand application requirement of various bioproducts very well, and apply the knowledge to design and modify their bioseparation process.	Can read and understand application requirement of various bioproducts very well, and apply the knowledge to design, modify and optimize their bioseparation process.

**Appendix 3: Assessment Form for Peer Evaluation**

Please indicate your perceptions of other team member’s contribution during the project development. Use the scale below for assessing each team member.

10-9	8-7	6-4	3-1	0
Demonstrate outstanding contributions and efforts during teamwork.	Exhibited appropriate effort in contributions during teamwork.	Made some contributions but greater effort could have been exhibited during teamwork.	Did not contribute much effort during teamwork.	Made no effort to contribute during teamwork.

Team member:											
<b>Preparation for work accomplishment:</b> completed readings.	10	9	8	7	6	5	4	3	2	1	0
<b>Task-related collaborative behavior:</b> task-focused, respectful of others, and cooperative.	10	9	8	7	6	5	4	3	2	1	0
<b>Team adjustment behaviors:</b> intra-team coaching, problem solving	10	9	8	7	6	5	4	3	2	1	0
<b>Work behaviors:</b> involved and participatory	10	9	8	7	6	5	4	3	2	1	0
<b>Communication:</b> information shared and exchanged, engaged in process, and made verbal contributions.	10	9	8	7	6	5	4	3	2	1	0
<b>Provide constructive feedback for this team member.</b> (Consisting of two to three sentences):											